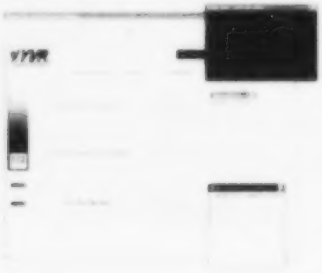
TP 14683E

COMMERCIAL VEHICLE DISPATCH SYSTEM



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Transport Canada

by
Vancouver International Airport Authority
and
IBI Group

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YVR

IBI GROUP

TP 14683E

COMMERCIAL VEHICLE DISPATCH SYSTEM

by
Steven Cook
Vancouver International Airport Authority
and
Homayoun Vahidi
IBI Group

January 2007

This project is part of Canada's Intelligent Transportation Systems (ITS) R&D Plan, *Innovation Through Partnership*, funded by the ITS Office of Transport Canada under the Strategic Highway Infrastructure Program (SHIP).

The Transportation Development Centre of Transport Canada served as technical authority of this project.

This report reflects the views of the authors and not necessarily those of Transport Canada.

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16. Abstract

The purpose of this project was to design and deploy an Intelligent Transportation System (ITS) solution for ground transportation management at Vancouver International Airport. IBI Group designed and developed a Commercial Vehicle Dispatch System (CVDS) incorporating the following key features:

- A central sub-system enabling the dispatch office to dispatch commercial buses, and manage the system using a web-based application.
- A mobile sub-system enabling curbside personnel to dispatch taxis and monitor conditions using hand-held computers, software, and wireless communications.
- A large eight-line variable message sign displaying dispatch requirements in the holding lot.
- A vehicle detection system for automatically updating dispatch requirements on the sign.

The resulting system has helped the airport to optimize its resources at the curb; lower passenger wait times through efficient dispatching; provide more detailed dispatch requests on the specific type of vehicle needed and the location they are needed at; minimize unnecessary oversupply, congestion, and idling at the terminals; and eliminate the reliance on a loud public address system.

Partly funded by Transport Canada's ITS Deployment and Integration Program, the project has successfully demonstrated the application of leading-edge, low-cost, and quickly deployable ITS solutions.

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16. Résumé

Ce projet visait à concevoir et déployer une solution STI (système de transport intelligent) pour la gestion des transports terrestres à l'aéroport international de Vancouver. Groupe IBI a conçu et développé un système d'affectation des véhicules commerciaux (SAVC) composé des éléments suivants :

- un sous-système central qui permet au bureau d'affectation d'affecter les autocars commerciaux, et de gérer le système à l'aide d'une application Web;
- un sous-système mobile qui permet aux préposés de la zone d'embarquement d'affecter les taxis et de suivre la situation à l'aide d'ordinateurs à main, de logiciels et d'appareils de communication sans fil;
- un grand panneau à message variable de huit lignes situé dans la zone d'attente des véhicules, sur lequel sont affichées les demandes de véhicules;
- un système de détection de véhicules qui sert à la mise à jour automatique des demandes de véhicules affichées sur le panneau.

Le système résultant a aidé l'aéroport à optimiser ses ressources aux points d'embarquement côté ville; grâce à une affectation efficace, les temps d'attente des passagers ont diminué; le système permet de préciser le type de véhicule demandé et l'endroit où il est demandé; il réduit la présence en surnombre de véhicules, la congestion et la marche au ralenti des moteurs; et il élimine la nécessité de recourir à un système de sonorisation bruyant.

Financé en partie par le Programme de déploiement et d'intégration des STI de Transports Canada, le projet a démontré de façon convaincante l'application de solutions STI d'avant-garde, économiques et rapidement déployables.

17. Mots clés	18. Diffusion
Système d'affectation des véhicules commerciaux, SAVC, système de transport intelligent, STI, gestion des transports terrestres aux aéroports	Ce document est disponible en ligne à www.tc.gc.ca/cdt/menu.htm

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Executive Summary

Previously, ground transportation management at Vancouver International Airport involved obsolete equipment, resulting in inefficient use of resources, maintenance difficulties, and poor information to commercial vehicles waiting in the airport's holding lot. The unreliable nature of the dispatch processes led to long passenger wait times, or oversupply of vehicles at the terminal, resulting in congestion and idling.

The objective of this project was to design, test, implement and evaluate a computer-based dispatch system for ground transportation management at the Vancouver International Airport Authority (VIAA). IBI Group designed and developed a Commercial Vehicle Dispatch System (CVDS) incorporating the following key features:

- A central sub-system enabling the dispatch office to dispatch commercial buses, and manage the system using a web-based application.
- A mobile sub-system enabling curbside personnel to dispatch taxis and monitor conditions using hand-held computers, software, and wireless communications.
- A large eight-line variable message sign displaying dispatch requirements in the holding lot.
- A vehicle detection system for automatically updating dispatch requirements on the sign.

A literature review of experience at other airports, and related technologies, was carried out to review best practices and lessons learned. It was found that the commercial vehicle management systems at other airports rely on automatic vehicle identification (AVI) technology for tracking of vehicles between the holding lot and the curbside, and that the use of wireless hand-held devices are planned/emerging at only a few of the airports.

A technology review of the following was carried out to document the state-of-the-art technologies available for incorporation into the CVDS design.

- Vehicle detection technologies
- Variable Message Sign (VMS) types
- VMS technologies
- Hand-held computers and personal digital assistants

The outcome of the technology review was used to validate the overall project approach – incorporating loop detectors and a full matrix VMS. It was also used to select a rugged hand-held computer for the system operators.

Once the functional requirements and concept of operations of the system were fully defined and approved, the design and implementation phase commenced and included the following key steps:

- System design
- Implementation

The flexible design of the CVDS allows it to be configured in different ways to meet the requirements of different customers. The system comprises the following major components:

- Vehicle loop detector
- VMS
- VIAA local area network
- Workstation

- Hand-held devices
- Central server equipment

The implementation phase was carried out jointly by the VIAA and IBI Group. The airport led the procurement of the sign and loop detector infrastructure, and managed their associated construction and installation activities. IBI Group led the software installation, testing and overall system integration task, ensuring that all components function as intended and are fully integrated with the CVDS software.

The resulting system has helped the VIAA to optimize its resources at the curb; lower passenger wait times through efficient dispatching; provide more detailed dispatch requests on the specific type of vehicle needed and the location they are needed at; minimize unnecessary oversupply, congestion, and idling at the terminals; and eliminate the reliance on a loud public address system.

Partly funded by Transport Canada's Intelligent Transportation Systems (ITS) Deployment and Integration Program, the project has successfully demonstrated the application of leading-edge, low-cost, and quickly deployable ITS solutions.

Sommaire

Auparavant, la gestion des transports terrestres à l'aéroport international de Vancouver se faisait au moyen d'équipements désuets. Il en résultait un gaspillage de ressources, des problèmes d'entretien et une information approximative sur les véhicules commerciaux présents dans la zone d'attente de l'aéroport. De plus, des processus d'affectation peu fiables causaient de longs temps d'attente aux passagers, ou une offre excédentaire de véhicules à l'aérogare, accentuant la congestion et la marche au ralenti des moteurs.

L'objectif de ce projet était de concevoir, tester, mettre en œuvre et évaluer un système d'affectation informatisé pour la gestion des transports terrestres à l'Administration de l'aéroport international de Vancouver (AAIV). Groupe IBI a conçu et développé un système d'affectation des véhicules commerciaux (SAVC) composé des éléments suivants :

- un sous-système central qui permet au bureau d'affectation d'affecter les autocars commerciaux, et de gérer le système à l'aide d'une application Web;
- un sous-système mobile qui permet aux préposés de la zone d'embarquement d'affecter les taxis et de suivre la situation à l'aide d'ordinateurs à main, de logiciels et d'appareils de communication sans fil;
- un grand panneau à message variable de huit lignes situé dans la zone d'attente des véhicules, sur lequel sont affichées les demandes de véhicules;
- un système de détection de véhicules qui sert à la mise à jour automatique des demandes de véhicules affichées sur le panneau.

Une recherche documentaire sur l'expérience d'autres aéroports et sur les technologies utilisées a fait ressortir les meilleures pratiques et les leçons à retenir. Ainsi, les systèmes de gestion des véhicules commerciaux aux autres aéroports, a-t-on constaté, s'appuient sur la technologie d'identification automatique des véhicules (IAV) pour le pistage des véhicules entre la zone d'attente et la zone d'embarquement. Seuls quelques-uns des aéroports recensés commencent à utiliser des dispositifs à main sans fil ou prévoient le faire bientôt.

Les technologies suivantes ont été examinées, afin de documenter les technologies de pointe susceptibles de faire partie du SAVC :

- technologies de détection des véhicules;
- types de panneaux à message variable (PMV);
- technologies de PMV;
- ordinateurs à main et assistants numériques personnels.

Les résultats de l'examen des technologies ont permis de valider l'approche globale du projet, soit le recours à des détecteurs en boucle et à des PMV à matrice dense. Il ont aussi aidé à choisir un ordinateur à main robuste pour les préposés.

Après que les besoins fonctionnels et le concept d'exploitation du système eurent été définis et approuvés, la phase de conception et de mise en œuvre a débuté. Elle comprenait les étapes suivantes :

- conception du système;
- mise en œuvre.

Le SAVC offre une grande souplesse et il peut être configuré en fonction des besoins précis des clients. Voici ses principales composantes :

- détecteur de véhicules en boucle
- PMV
- réseau local de l'AAIV
- poste de travail
- dispositifs à main
- serveur central

La phase de mise en œuvre a été réalisée par l'AAIV en collaboration avec Groupe IBI. L'aéroport s'est occupé de l'achat du panneau à message variable et des détecteurs en boucle, et a géré la pose des détecteurs dans la chaussée et l'installation du panneau. Groupe IBI a dirigé l'installation des logiciels, les essais et l'intégration du système, en s'assurant que toutes les composantes fonctionnent comme prévu et s'harmonisent parfaitement avec le logiciel du SAVC.

Le système résultant a aidé l'aéroport à optimiser ses ressources aux points d'embarquement côté ville; grâce à une affectation efficace, les temps d'attente des passagers ont diminué; le système permet de préciser le type de véhicule demandé et l'endroit où il est demandé; il réduit la présence en surnombre de véhicules, la congestion et la marche au ralenti des moteurs; et il élimine la nécessité de recourir à un système de sonorisation bruyant.

Financé en partie par le Programme de déploiement et d'intégration des systèmes de transport intelligents (STI) de Transports Canada, le projet a démontré de façon convaincante l'application de solutions STI d'avant-garde, économiques et rapidement déployables.

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List of Acronyms

AGTA	Airport Ground Transportation Association
AVI	Automatic Vehicle Identification
CCTV	Close Circuit Television
CVD	Commercial Vehicle Dispatch
CVDS	Commercial Vehicle Dispatch System
CVI	A third party system in use at the VIAA to manage the registration of commercial vehicles and their parking placement at the terminals
DTB	Domestic Terminal Building
FIFO	First In, First Out
GPS	Global Positioning System
GTP	Ground Transportation Personnel
GUI	Graphical User Interface
IR	Infrared
IT	Information Technology
ITB	International Terminal Building
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LED	Light Emitting Diode
LPR	License Plate Recognition
PA	Public Address
PDA	Personal Digital Assistant
R&D	Research & Development
RFP	Request for Proposal
VIAA	Vancouver International Airport Authority
VLD	Vehicle Loop Detector
VMS	Variable Message Sign
WAT	Wheelchair Accessible Taxi
YVR	Vancouver International Airport

1. INTRODUCTION

The purpose of this project was to develop and deploy a computer-based dispatch system for commercial vehicles at the Vancouver International Airport Authority (VIAA), incorporating efficiencies of wireless communication, changeable message sign displays, and hand-held computers, to achieve an efficient, secure, and low vehicle emissions operation, at relatively affordable capital and operating costs.

The proposed dispatch was envisioned to:

- Enable vehicles to be called to the terminal curb on an "as required" basis, minimizing the curb-side vehicle idling time and minimizing curb-side congestion.
- Display the call up information on a variable message sign in the vehicle holding area, and on a monitor in the holding area's lunch room.
- Record that the commercial vehicle is en route from the holding area to the curb when dispatched.
- Provide operator access to the system through central computer and hand-held, wireless Personal Digital Assistant (PDA).

This report provides a summary of the project activities and tasks leading to the deployment of a computer-based dispatch system for commercial vehicles operating at VIAA.

1.1 Project Objectives

The objective of this project was to design, test, implement and evaluate a wireless commercial vehicle dispatch system; Exhibit 1-1 provides a breakdown of the project objectives in terms of the operational objectives for the Vancouver International Airport, and the Research & Development objectives for Transport Canada.

Exhibit 1-1: Project Objectives

Operational Objectives for the Vancouver International Airport	Research & Development (R&D) objectives for Transport Canada
Reduce the staffing requirements at the curb side.	Use of vehicle detection technology instead of AVI technology
Reduce vehicle idling at the curb.	Use of wireless hand-held devices for dispatching and sign control instead of a workstation
Reduce vehicle congestion at the curb.	Customized software to integrate the above referenced features into existing commercial vehicle dispatch software
Enhanced display of commercial vehicle call up information.	
Reduce user/passenger waiting time for vehicles.	

1.2 Project Process & Deliverables

This project was carried out over a one year period starting in April of 2005 leading to system acceptance in April of 2006. Full start-up of the system was in June of 2006 to support VIAA's staffing and transition plan to the new system.

The following combination of formal and informal deliverables were prepared during the course of the project for the purposes of documenting approach and obtaining signoff on design issues from the VIAA.

- Detailed Work Plan
- Literature Review
- Technology Review
- Concept of Operations
- Software Requirements Specification
- Equipment Specification
- Interim Report
- User Acceptance Test Plan
- System Administration Manual
- Users Manual
- Training Documentation
- Final Report (this document)

This report was prepared by IBI Group and the VIAA, summarizing the key aspects of this project for submission to Transport Canada.

2. LITERATURE REVIEW

A literature review of experience at other airports, and related technologies, was carried out to review best practices and lessons learned. The following sections summarize the outcome of this review.

2.1 Experience at Other Airports

A scan of application of the commercial vehicle dispatch and Automatic Vehicle Identification (AVI) systems at some of the airports in North America was conducted recently to provide a snapshot of the current state of the industry in the technological application for landside commercial vehicle operations. A summary of the scan is provided in Exhibit 2-1. The following airports have been covered:

- Logan International Airport, Boston, MA
- Dulles Int'l Airport, Washington D.C.
- Winnipeg Int'l Airport, Winnipeg, Manitoba
- Toronto Pearson Int'l Airport, Toronto, Ontario
- San Francisco International Airport, San Francisco, CA
- Minneapolis-St. Paul International Airport, Minneapolis, MN
- Chicago O'Hare International Airport, Chicago, IL
- Dallas-Fort Worth Int'l Airport, Dallas-Fort Worth, TX
- Palm Springs International Airport, Palm Springs, CA
- Honolulu Int'l Airport, Honolulu, HI
- Calgary International Airport, Calgary, Alberta
- Phoenix Sky Harbor International Airport, Phoenix, AZ

For each airport, the following information is tabulated:

- location
- type of commercial vehicle management system including information that is tracked,
- purpose and objectives of the system,
- technologies used
- current status of the system.

Exhibit 2-1: Literature Review – Summary of Similar Systems

AIRPORT	LANDSIDE COMMERCIAL VEHICLE MANAGEMENT INITIATIVE	SYSTEM FEATURES	PRIMARY TECHNOLOGIES DEPLOYED	STATUS	Relevance to this project
1. Logan International Airport Boston, MA	AVI System is under consideration	Current system uses the token system with ticket for trip fee collection which is old and hard to maintain. Limo trip fee collection is by manual collection conducted in the office. The new AVI system is to facilitate a comprehensive system that would enhance passengers' intermodal transfer at the airport's commercial vehicle operations through the incorporation of features such as improved flight arrival based dispatch, automated terminal curb management, contracted services monitoring and trip fee assignments with dwell time monitoring and charges.	Current System: Token machines with paper ticket for taxis. VMS for manual dispatch of taxis assisted by PA. Technologies for the new AVI system are currently under study.	Currently under consideration and RFP for the AVI system under development Smart card is also under consideration to replace the current token based fee collection system if funding is insufficient for AVI implementation.	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.

AIRPORT	LANDSIDE COMMERCIAL VEHICLE MANAGEMENT INITIATIVE	SYSTEM FEATURES	PRIMARY TECHNOLOGIES DEPLOYED	STATUS	Relevance to this project
2. Dulles Int'l Airport Washington D.C.	AVI System under consideration	Current system applies annual charge based on statistics of annual trips but the airport believes the number of trips in the current statistics is under reported. Dispatch taxis manually with the curb side starters radio the dispatcher at the holding area who in turn summon taxis using the VMS (each driver picks up a number when enter the holding area).	Current system: VMS to assist manual dispatching to display the number FIFO No gates New AVI System: AVI for tracking and trip fee collection Automatic dispatch with VMS Wireless handheld is part of the phased deployment	The RFP is on-hold due to funding issue.	Use of wireless hand-held devices is part of a phased deployment; depending on timing relative to this project, experience and lessons learned can be shared between the projects. Since vehicle detection technologies are not employed here, their application in this project will also add to the current ITS knowledgebase.
3. Winnipeg Int'l Airport Winnipeg, Manitoba	AVI System for taxis and limos	Collect trip fee based on per trip usage. Automate dispatching of taxicabs and limousines for passenger pickup at terminal curbs. Enhance revenue collection process.	AVI VMS	Operational	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.

AIRPORT	LANDSIDE COMMERCIAL VEHICLE MANAGEMENT INITIATIVE	SYSTEM FEATURES	PRIMARY TECHNOLOGIES DEPLOYED	STATUS	Relevance to this project
4. Toronto Pearson Int'l Airport Toronto, Ontario	AVI System for commercial vehicle fleets (AVI for parking is also operational)	Track commercial vehicle fleets at all Arrivals/Departures and multiple holding areas; Automate dispatching of taxicabs, limousines, and AGTA vehicles for passenger pickup at terminal curbs; Collect trip fees based on usage; Provisions have been made for dwell time charges and monitoring.	AVI VMS (for dispatch) Blank out signs (for confirmation of valid AVI reads) Curbside computers (wired connection to LAN) Gates and card readers were used initially but removed to speed up the process Wireless handheld devices are considered if funding is available.	Operational (the current system went through 4 phases to reach the current state)	Use of wireless hand-held devices is being considered; depending on timing relative to this project, experience and lessons learned can be shared between the projects. Since vehicle detection technologies are not employed here, their application in this project will also add to the current ITS knowledgebase.
5. San Francisco International Airport San Francisco, CA	AVI System for commercial vehicle fleets	Track taxis, limousines and courtesy vehicles/shuttle buses (serving rental car companies and hotels) based on curb side dwell time and per trip usage. Monitor trip activity of commercial vehicles and automatically generate reports used for planning, operations, accounting, management and enforcement.	AVI VMS	Operational The Airport is considering automatic dispatch of taxis and limos as an upgrade	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.

AIRPORT	LANDSIDE COMMERCIAL VEHICLE MANAGEMENT INITIATIVE	SYSTEM FEATURES	PRIMARY TECHNOLOGIES DEPLOYED	STATUS	Relevance to this project
6. Minneapolis-St. Paul International Airport Minneapolis, MN	AVI System for commercial vehicle fleets (and revenue parking)	Charge trip fee on usage for commercial vehicle fleets except airport operated vehicles. Charge dwell time on usage for most of the commercial vehicle fleets except taxis which are dispatched by the system. Automatic dispatch of taxis to two staging areas before the curb loading zone.	AVI VMS (both at curbs and holding area) Gates w/ loops Ticket spitters Card readers (for some lots) Wireless handheld device is required in the new RFP Biometric device is being considered for security purpose	Operational A new RFP is currently open to replace the AVI software, not hardware.	Use of wireless hand-held devices is being considered; depending on timing relative to this project, experience and lessons learned can be shared between the projects. Since vehicle detection technologies are not employed here, their application in this project will also add to the current ITS knowledgebase.
7. Chicago O'Hare International Airport Chicago, IL	AVI System for commercial vehicle fleets is under consideration (AVI system for parking is operational)	The proposed AVI system for commercial vehicles include: Trip fee and dwell time charges Automatic dispatch of taxis Curbside wireless handheld computers for dispatch and enforcement Curbside enforcement	The proposed AVI System will have: AVI VMS Blank out signs (for confirmation of AVI reads) Curbside monitors for enforcement and taxi arrival display Taxi driver lounge dispatch monitors Wireless handheld devices	Under consideration	Since vehicle detection technologies are not employed here, their application in this project will also add to the current ITS knowledgebase.

AIRPORT	LANDSIDE COMMERCIAL VEHICLE MANAGEMENT INITIATIVE	SYSTEM FEATURES	PRIMARY TECHNOLOGIES DEPLOYED	STATUS	Relevance to this project
8. Dallas-Fort Worth Int'l Airport Dallas-Fort Worth, TX	AVI System for commercial vehicles under consideration (AVI system for revenue parking is operational)	Control access to restricted access service areas of the airport. The airport authority has recently awarded (early 2005) a consultant assignment to generate an ITS strategic plan for the airport including the upgrade to the existing fee collection system for landside commercial vehicles to include AVI based automatic dispatch of taxis and limos.	To be determined. AVI and VMS are in the requirements of the ITS master plan.	Under consideration as part of an ITS Master Plan.	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.
9. Palm Springs International Airport Palm Springs, CA	AVI System	Collect trip fees based on per trip usage. Automatically dispatch taxis.	AVI VMS Blank out signs (for confirmation of AVI reads)	Operational	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.
10. Honolulu Int'l Airport Honolulu, HI	AVI system	Track commercial vehicles only. Trip fee collection and taxi automatic dispatch system to be future upgrade	AVI	Operational	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.

AIRPORT	LANDSIDE COMMERCIAL VEHICLE MANAGEMENT INITIATIVE	SYSTEM FEATURES	PRIMARY TECHNOLOGIES DEPLOYED	STATUS	Relevance to this project
11. Calgary International Airport Calgary, Alberta	AVI System	Track commercial vehicle fleets Trip fee collection Automatic taxi dispatch	AVI VMS	Operational	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.
12. Phoenix Sky Harbor International Airport Phoenix, AZ	AVI System under design and installation GPS for airport operated buses under design and installation (not inquired)	Track commercial vehicle fleets Collect information required for proper and timely billing of commercial vehicle operators Provide automatic taxicab dispatch services	AVI VMS	Installation underway	Use of vehicle detection technologies and wireless hand-held devices are not part of this airport's system; therefore, the R&D elements of this project will contribute to the current ITS knowledgebase.

As noted in Exhibit 2-1, all of the commercial vehicle management systems at other airports (reviewed as part of this literature review) rely on AVI technology for tracking of vehicles between the holding lot and the curb-side, and that the use of wireless hand-held devices is planned/emerging at only a few of the airports. As a result, the R&D attributes of this project provide a significant addition to the current ITS knowledgebase by employing lower cost vehicle detection technologies instead of AVI, deployment of wireless hand-held devices in the short-term, and the development of new software to integrate these alternate technologies with existing software. Also, the experience gained with the use of hand-held devices under this project will be of immediate benefit to the airports that plan to employ them – such as at Pearson International Airport in Toronto.

2.2 Technology Review

A technology review was carried out to document the state-of-the-art technologies available for incorporation into the CVDS design. This technology review considered the following areas:

- Vehicle detection technologies
  - Inductive Loops
  - Doppler Microwave Radar
  - True Presence Microwave Radar
  - Passive Infrared (Passive IR)
  - Active Infrared (Active IR)
  - Ultrasonic
  - Video Detection Systems
  - Automatic Vehicle Identification (AVI)
  - License Plate Recognition (LPR) Technology
- Variable Message Sign (VMS) Types
  - Discrete Character Matrix
  - Line Matrix
  - Full Matrix
  - Combination
- Variable Message Signs Technologies
  - Fibre Optic
  - Light Emitting Diode Signs (LED)
  - Hybrid
  - Hand-held computers
- Hand Held Computers & PDAs

The outcome of the technology review was used to validate the overall project approach – incorporating loop detectors and a full matrix VMS. It was also used by the VIAA to select a rugged hand-held computer for the system operators.

3. OPERATIONS PRIOR TO THE NEW CVDS

The pre-existing operation for dispatching commercial vehicles at VIAA was reviewed as a first step for defining the requirements of the new system. The management of commercial vehicles at the VIAA involved three major components:

- A commercial vehicle holding area, located east of the International Terminal Building (ITB) provides a storage lot for taxis, limos, and buses while they wait their turn to be called up to the terminals. The holding area includes a call-up display (Exhibit 3-2) for indicating the number of taxis that are to be dispatched, and a PA system for dispatching of specific taxis and buses. Exhibits 3-1 and 3-3 present illustrations and photographs of the holding area.
- The Ground Transportation Personnel (GTP) manage the movement of taxis and commercial vehicles between the holding area and the terminal. Exhibits 3-4 and 3-5 present photographs of the domestic and international terminal curb-sides where the GTP operate.
- A dispatch office maintains radio communications with the GTP, has the ability to monitor the holding area using CCTV monitors, and announce messages to the holding area via a PA system. Exhibit 3-6 presents photographs of the dispatch office.

The overall operation of commercial vehicles at the VIAA is summarized in the form of a flow-chart in Exhibit 3-7. These operations are described in more detail in the following sections:

- The types of commercial vehicles currently operating at the VIAA.
- Arrival and registration procedures for the commercial vehicles.
- Dispatching of the commercial vehicles by the GTP and dispatch office.
- Issues associated with the pre-existing system and its operation.

Exhibit 3-1: Layout of Holding Area

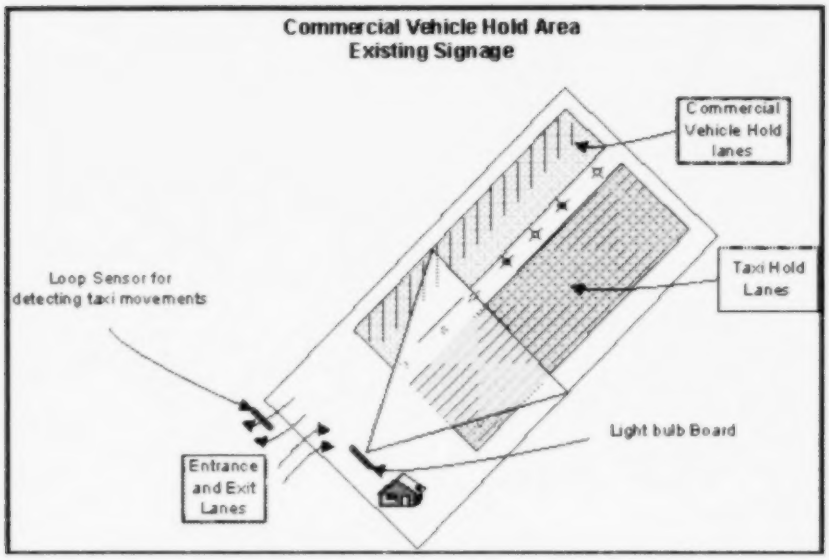


Exhibit 3-2: Pre-existing Call-up Board

Exhibit 3-3: Holding Area Photographs

- Holding Area
- Looking north
- Taxi Queue

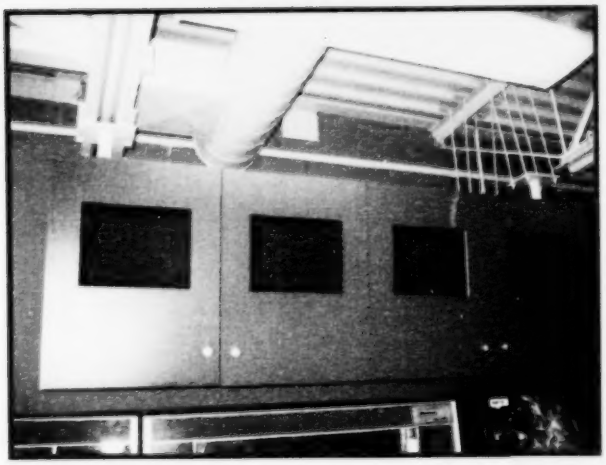
- Holding Area
- Looking north-west
- Bus Parking

- Holding Area
- Looking south
- Exit Lanes

.../Exhibit 3-3 continued

- Holding Area
- Looking south from end of Taxi queue towards call-up board

- Holding Area
- PA speakers and telephone locations for commercial buses



- Holding Area lunch room, monitor bank

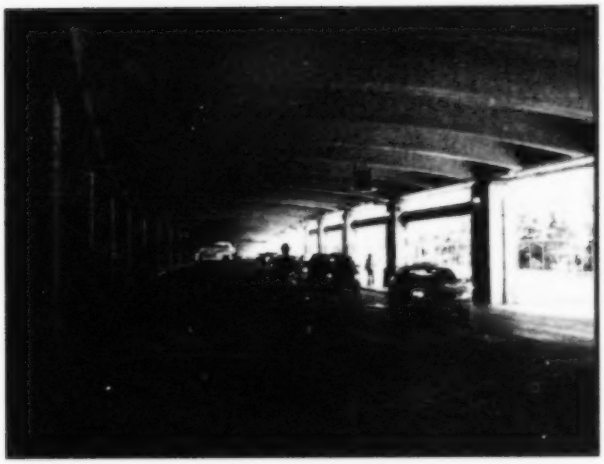
Exhibit 3-4: Domestic Terminal

- Domestic Terminal
- Looking south
- Taxi Queue

- Domestic Terminal
- Looking north
- Taxi Queue

- Domestic Terminal
- Looking south
- Bus loading area

Exhibit 3-5: International Terminal



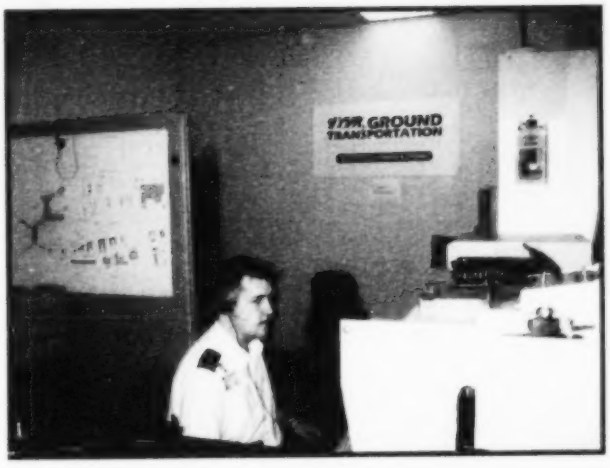
- International Terminal
- Looking east
- Taxi Queue

- International Terminal
- Looking east
- Taxi Queue

- International Terminal
- Looking south-east
- Taxi Queue

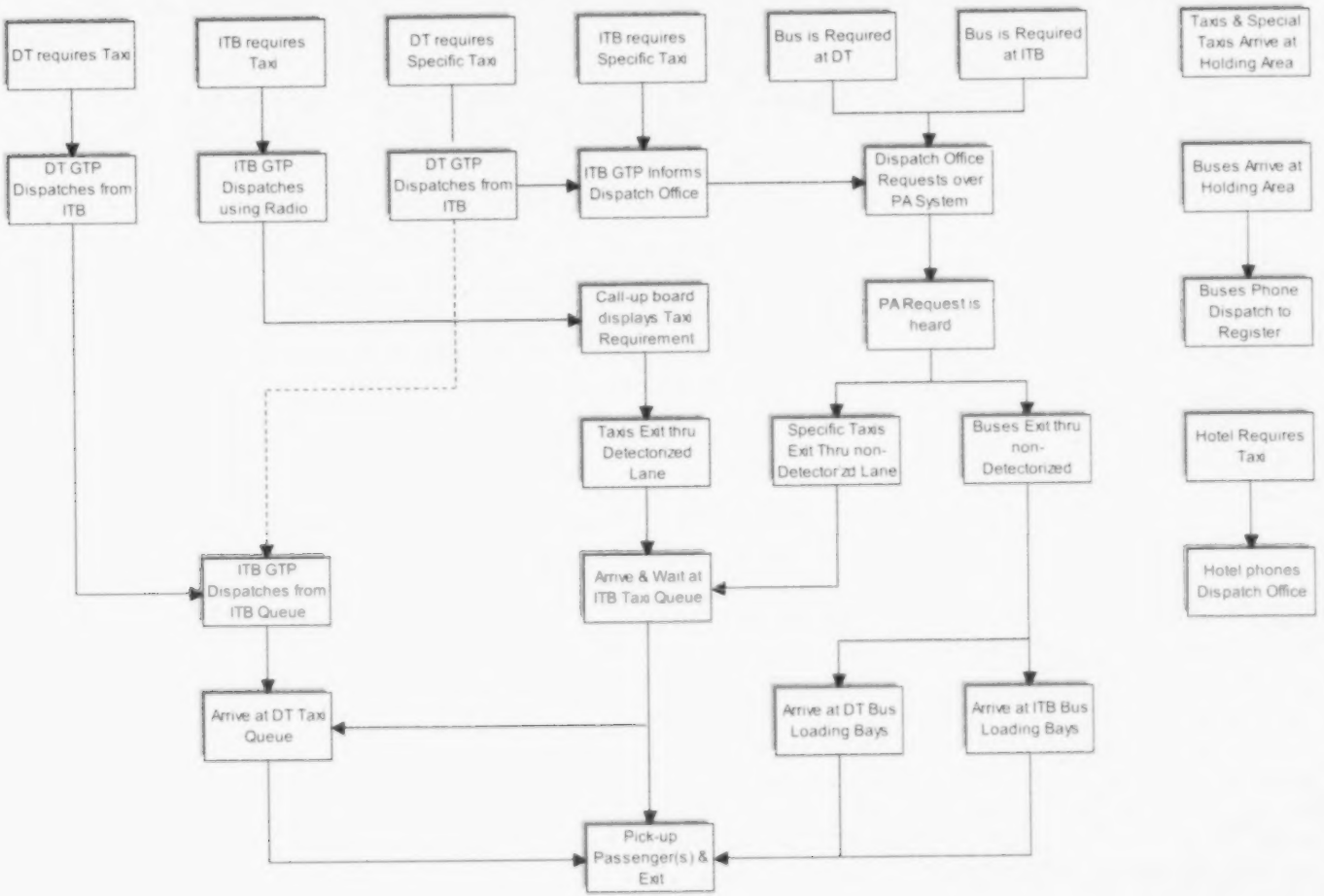
Exhibit 3-6: Dispatch Office

- VIAA Dispatch Office



- VIAA Dispatch Office

Exhibit 3-7: Overview of Existing Operations


DT requires Taxi
ITB requires Taxi
DT requires Specific Taxi
ITB requires Specific Taxi
Bus is Required at DT
Bus is Required at ITB
Taxis & Special Taxis Arrive at Holding Area
DT GTP Dispatches from ITB
ITB GTP Dispatches using Radio
DT GTP Dispatches from ITB
ITB GTP Informs Dispatch Office
Dispatch Office Requests over PA System
Buses Arrive at Holding Area
Call-up board displays Taxi Requirement
PA Request is heard
Buses Phone Dispatch to Register
Taxis Exit thru Detectorized Lane
Specific Taxis Exit Thru non-Detectorzd Lane
Buses Exit thru non-Detectorized
Hotel Requires Taxi
ITB GTP Dispatches from ITB Queue
Arrive & Wait at ITB Taxi Queue
Hotel phones Dispatch Office
Arrive at DT Taxi Queue
Arrive at DT Bus Loading Bays
Arrive at ITB Bus Loading Bays
Pick-up Passenger(s) & Exit

3.1 Commercial Vehicle Types

There are three categories of commercial vehicles that require groundside management and dispatching at the VIAA; these include:

1. Regular "on demand" taxis.

2. Specifically requested "on demand" taxis (i.e. wheelchair accessible, customer-specified taxi companies, or other specific taxi styles).

3. Commercial buses.

All of these vehicles participate in a licensing and registration scheme with VIAA in order to operate at the airport. Since the CVDS does not incorporate automatic vehicle identification (AVI) capabilities for vehicle tracking, the licensing and registration schemes are not covered in this document and not impacted by the CVDS.

3.2 Arrival / Registration

Commercial vehicles arriving at the VIAA first park at the holding area located east of the ITB. As shown in Exhibits 3-1 and 3-3, the holding area is long and narrow (approximately 245 m long), and provides space for taxis and limos to queue up, as well as parking spaces for commercial buses.

The entrance to the holding area does not include monitoring capabilities for identifying and registering commercial vehicles as they arrive into the holding area. Taxis and limos arriving at the holding area are not tracked and are not required to register with the dispatch office. The dispatch office is capable of using the CCTV monitors to determine whether taxis or limos are present in the holding area. Commercial buses arriving at the holding area are required to park their buses in the dedicated spots and register their arrival using dedicated phones in the holding area. The phones provide a connection to the dispatch office; upon calling in, the dispatch office logs pertinent information associated with the commercial bus into a separate system.

3.3 Dispatching

The following sections describe the pre-existing procedures for dispatching taxis, specific taxis, and commercial buses to the terminal. It should be noted that dispatching from the DTB is not covered in this section; dispatching at the DTB relies on the GTP that are at the ITB, and on the dispatch office. Therefore, the presence of a new system will be transparent to the dispatching tasks at the DTB.

3.3.1 Taxis

The GTP are responsible for dispatching taxis to the curb side at the airport terminals. The GTP use specially designed radios to send messages to a call-up board located in the holding area.

When the GTP located on Level 2 of the ITB requires taxis at the curb, their radio's numeric keypad is used to enter the number of taxis required. This number (maximum of 9) is displayed on the call-up board in the holding area. An audible alarm (beep) is supposed to be heard in the holding area to attract the drivers' attention (however this functionality is currently not working). Based on the number displayed on the call-up board in the holding area, taxis at the head of the queue exit the holding area and drive to the ITB. Regular taxis use a detectorized exit lane in order to trigger a "countdown" functionality on the call-up board. As taxis exit the holding area over the detectorized lane, the GTP is supposed to hear a "beep" per vehicle as an audible countdown of the number of vehicles approaching the terminal. However, this does not work consistently.

3.3.2 Specifically Requested Taxis

For the dispatching of specifically requested taxis, the GTP uses a hand-held radio to communicate the request to the dispatch office. The dispatch office uses the PA system in the holding area to call up the specifically requested taxi to the part of the terminal where it is needed. The specifically requested taxis exit the holding area using the lane that is not detectorized. The GTP provides confirmation that the requested taxi has arrived at the appropriate location; if the vehicle does not arrive, the GTP repeats the dispatch process through the dispatch office. The GTP also has access to the PA system to directly dispatch from the holding area, for times when the dispatch office is busy or unavailable.

3.3.3 Commercial Buses

The dispatching of commercial buses is similar to that of the specially requested taxis. When a commercial bus is needed at the terminal, the tour organizer or other person responsible for the tour group calls the dispatch office. The dispatch office uses the CVI system (a third party system in use at the VIAA to manage the registration of commercial vehicles and their parking placement at the terminals) to select a bus bay at the terminal for the bus, and uses the PA system in the holding area to ask the specific commercial bus to proceed to that bus bay. The commercial buses exit the holding area using the exit lane that is not detectorized. The dispatch office uses the CCTV monitors to confirm the arrival of the commercial buses at the appropriate bus bay.

3.4 Operational Issues Prior to the New CVDS

The pre-existing procedures and systems described in the previous sections are impeded by a number of system and/or operational issues that prevent the VIAA from efficient management and dispatching of commercial vehicles. These include:

- The radios used by the GTP have not been manufactured for many years, and are therefore very difficult to maintain.
- The audible alarm intended to tell the GTP that taxis are exiting the holding area is not working properly.
- The existing taxi call-up board was originally installed in the early 1970s and has passed the end of its useful life. The technology has been outdated for many years and is operationally inefficient. The call-up board is also very difficult to maintain.
- The call-up board is limited to displaying only a single digit; therefore, the GTP can only call up a maximum of 9 taxis at a time.
- The audible alarm intended to notify the taxis in the holding area that a new number is being displayed on the call-up board, does not work currently.
- Commercial buses exiting the holding area using the non-detectorized lane sometimes activate the detector due to their large size.
- Use of the PA system to dispatch special taxis and commercial buses has to be loud enough to be heard in the airport environment; some noise complaints have been received from residents as far as the Marpole area north of Richmond in Vancouver.

4. OVERVIEW OF PROPOSED SYSTEM

The objective of the new CVDS is to improve the "dispatching" aspect of the operations at the ITB described in the previous section; the existing vehicle types, their arrival and registration procedures, and the operations at the domestic terminal will not be impacted by the new CVDS system. The new CVDS system is intended to improve the dispatching capabilities by way of the following:

- Installation of a large variable message sign (VMS) capable of displaying multiple messages associated with the type and quantity of taxis, specifically requested taxis, as well as commercial buses.
- Replacement of the GTPs' handheld radios with a handheld computer for calling up the type and quantity of taxis, and receiving confirmation of their departure.
- Provision of a central server/work-station and central software at the dispatch office for dispatching commercial buses using the new VMS.

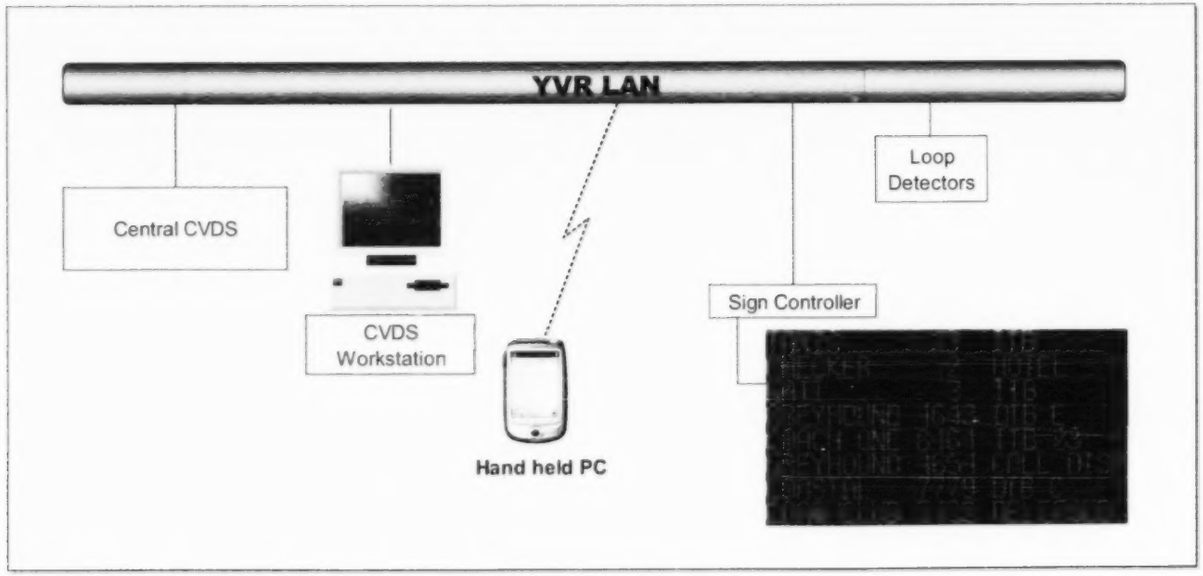
Exhibit 4-1A illustrates an overview of the proposed CVDS in terms of its area of coverage; Exhibit 4-1B presents an overview of the CVDS subsystems. The following briefly describes these subsystems.

- **Central System:** The central system comprises the central server on which the new CVDS application resides, and the workstation from which the dispatch office operators use the system. The central system provides the operator at the dispatch office with all of the functions accessible to the GTP via their hand-helds, plus additional functionality associated with the dispatching of buses, as well as reporting and system configuration.
- **Variable Message Sign:** As illustrated in Exhibit 4-1B, the Variable Message Sign (VMS) is a large LED sign that displays the dispatch information for general taxis, specific taxis, and commercial buses.
- **Hand-Held Computers:** The hand held computers allow the GTP to dispatch taxis and special taxis. In addition to being a rugged device suitable for continuous operation in the outdoor airport environment, a key requirement of the hand held device is the ability to be recharged without compromising the GTP dispatching tasks.
- **Loop Detectors:** A loop detector located along one of the two exit lanes in the holding area is used to count the number of taxis leaving the holding area, and enabling a countdown functionality on the VMS. The central system time-stamps and logs detector actuations so that reports can be generated in the future.

Holding Area
DTB Zone
ITB Zone
Dispatch Office
Loop Detectors
Dynamic Message Sign

Exhibit 4-1 A
CVDS Overview

Exhibit 4-1 B
Main CVDS
Subsystems



5. CONCEPT OF OPERATIONS

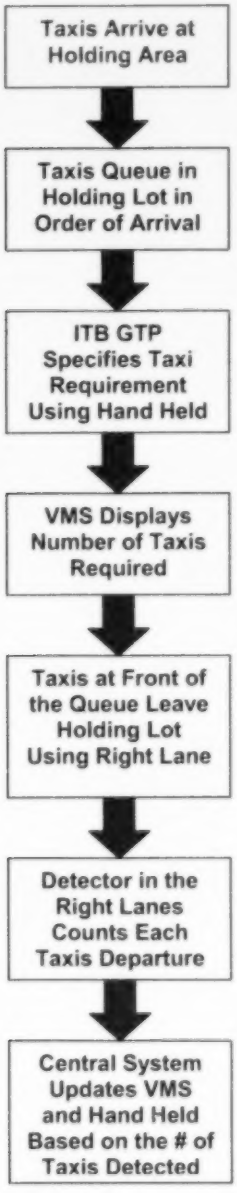
This section describes the concept of operations for managing and dispatching general taxis, specific taxis, and buses, using the new CVDS.

5.1 Taxis

The operation of the CVDS for the dispatching of taxis is described in terms of the following functional elements; Exhibit 5-1 provides a summary of the taxi dispatch operations.

- Summoning taxis (from the terminal curb);
- Dispatching taxis (from the commercial vehicle holding area);
- Detecting taxis (at the exit of commercial vehicle holding area);
- Fail-safe Provisions

Exhibit 5-1: Taxi Dispatch Operations


Taxis Arrive at Holding Area
Taxis Queue in Holding Lot in Order of Arrival
ITB GTP Specifies Taxi Requirement Using Hand Held
VMS Displays Number of Taxis Required
Taxis at Front of the Queue Leave Holding Lot Using Right Lane
Detector in the Right Lanes Counts Each Taxis Departure
Central System Updates VMS and Hand Held Based on the # of Taxis Detected

5.1.1 Summoning Taxis

The GTP at the terminal curb manage the daily operations of taxis between the commercial vehicle holding area and the terminal curbs. One of the functions of the GTP at the terminal curbs is to monitor the demand for taxis (by arriving passengers) and the supply of taxis at the curb loading zones (both ITB and DTB). When the taxi supplies at the terminal curbs are low, the GTP at ITB requests additional taxis from the holding area to maintain an adequate supply of taxis at the ITB (for both ITB and DTB) to maintain the level of service required. This process will be accomplished

by the GTP at the ITB through the use of a rugged wireless handheld device to request the number of taxis to be dispatched from the holding area on the Variable Message Sign (VMS). The handheld devices communicate with the central system which in turn communicates directly with the VMS to display messages.

Only the GTP at the ITB are responsible for summoning the taxis for both ITB and DTB (a future option is to allow GTP at both ITB and DTB to summon taxis for their respective terminal). This is consistent with the pre-existing practice and simplifies the dispatch operation with one consolidated request based on the demand at the curbs.

The Graphical User Interface (GUI) of the hand-held computers supports three basic requirements for summoning taxis:

1. ***Quantity:*** The first GUI allows the GTP to enter any number from 1 to 99 and display the number of regular taxis needed on the VMS (the first row). This number will be reduced (a count down process) as the taxis leave the holding area (as detected by the exit detector in the right exit lane of the holding area). A new request for additional regular taxis will not be shown on the VMS until the previous request counts down to zero; specifically, the system will allow the GTP to summon the next group of regular taxis multiple times regardless of the VMS display count-down status. The system will retain each summoning request from the handheld device but only displays the next number on the VMS when the first group of taxis completes exiting the holding area (count-down to zero). This process would avoid more taxis leaving the holding area than summoned. For instance, if the first request is for 5 taxis, and half way through the count-down (to 3) the number changes to 6 (as the result of a new request of 3), taxi drivers could be confused and more taxi drivers have the excuse or reason to leave the holding area, resulting in too many taxis at the staging area of ITB.

If the GTP requests a number of taxis which is very large, the GUI will prompt with an "Are you sure" message. This will allow the GTP to fix a mistake before it is posted. The definition of "very large" is controlled by a system parameter.

2. ***Type:*** The second GUI allows the GTP to request specific types of taxis, including specific taxi companies, WAT enabled (wheelchair accessible), or other specific taxi styles. The number, type, and location for the specific taxis can be requested and displayed. More detailed discussion on Specific Taxis is provided in Section 5.2.

3. ***Destination:*** The GUI will also allow the GTP to pick a destination other than the default ITB, such as the hotel or the DTB at the airport.

The GUIs have supporting capabilities to cancel or modify a request, whether that request is pending, or currently being shown on the VMS.

5.1.2 Dispatching Taxis

Taxis will be dispatched from the holding area via a new VMS that is triggered and controlled by the CVDS. The first row of the VMS will be used exclusively for displaying general taxi requirements:

Taxis ## Location (ITB, DTB, Hotel) - where ## is any two digit number

When the number of taxis summoned by the GTP is displayed on the VMS at the holding area, taxis at the front of the queue will leave the holding area through the right exit lane to the ITB staging area. The detector in the right exit lane detects the number of taxis exiting and reports to the system to allow a real time count down of the number of taxis still required.

Exhibit 5-2 provides a summary table showing the steps of taxi operations and corresponding capability of the system at various functional areas of the groundside operation with regular text indicating existing practice and italics for new system operation.

Exhibit 5-2: General Taxi Operations & CVDS Functions

Functions & Capabilities / Process	Curb-side	Holding Lot
Arrive at holding lot	• N/A	• Queue in holding lot.
Taxi Needed at ITB	• *Enter # of taxis needed on hand-held device*	• *Number of taxis needed displayed on VMS*
Departure from holding lot	• *Hand-held device shows count down of the number of taxis still required*	• Taxis exit using detectorized exit lane • *Dispatch number on VMS counts down to zero*
Arrival at ITB	• Visual confirmation • ITB GTP dispatches requested number of taxis to DTB	• N/A
Arrival at DTB	• Visual confirmation	• N/A

5.1.3 Detecting Taxis

When taxis exit the holding area, they are required to exit through the right lane where a new loop detector is installed. Every time a vehicle is detected, the number displayed on both the handheld and the VMS will automatically be reduced by one. This functionality is dependent on the taxis using the detectorized lane.

5.1.4 Fail Safe Provisions

The following describes the exceptions and potential impacts for the dispatch operation:

- If the exit detector fails, the system is still able to dispatch taxis but the GTP and taxi drivers will need to be aware that the count down function is not available. The system may be able to inform all the users of the system if the failure of the exit detector can be identified. This informing could be a flashing threshold number on the handheld for the GTP and an additional character on the first row of the VMS for taxi drivers. In this case the system would be operating in a degraded mode. The capability of the new detector to be monitored for faults will depend on the architecture of the system, and selected devices.
- If the handheld fails, the system can still operate in a degraded mode as the GTP can communicate (through radio or phone as the backup) with the Dispatch Office to display the number of taxis required through the CVDS workstation at the Dispatch Office.
- If either the VMS, central server, power or communications network fails, the dispatch operation will be completely reverted back to a manual operation with radio and PA. This is contingent on the radio and the PA systems being retained for manual dispatching as the fallback operation (including down times due to system maintenance).

5.2 Specific Taxis

Specific taxis include the following:

- customer specified taxi companies
- WAT enabled (wheelchair accessible)
- Other specific taxi styles, such as pet friendly, 5 passenger, etc.
- Specific taxis can be summoned by the ITB GTP directly through the handheld devices.

5.2.1 Summoning Taxis

The summoning of taxis will be via the system's GUI as described in section 5.1.1. The GUI allows the GTP to select the type, quantity, and destination of specific taxis.

5.2.2 Dispatching Taxis

The VMS will display the dispatch information for specific taxis on its second and third lines, since the first line is permanently reserved for general taxis.

Three options were considered for managing the information associated with the specific taxis:

- Option 1 (Original Project Requirement): Taxis exit using the non-detectorized lane; the displayed quantity of the special taxis on the hand-held or VMS is not counted down until manually adjusted by the GTP or dispatch office.
- Option 2 (New Requirement by YVR, and selected for implementation): Taxis exit using the detectorized lane; since no distinction will exist between regular and specific taxis, the displayed quantity on the VMS and handheld will be adjusted every time a taxi exits. The requests on the VMS will be counted down line by line, in the order the requests came in. This may introduce an error in the quantity information displayed depending on a number of factors explained later in this section.

- Option 3 (Alternate to Option 2): Taxis exit using the second lane (proposed to not be detectorized); however, the second exit lane is also detectorized, with a loop and height detector, which will be used to distinguish buses, and thus assume all other vehicles are specific taxis for proper countdown. This approach will be very accurate, but costlier than Option 2. A variation of this option would be to use video detection instead of both the loop and height detection; however, this option has not been discussed in this document as it would impact the project budget and schedule more significantly.

It should be noted that Option 2 has the potential for erroneous messages to be displayed on the VMS and hand held device, and could reduce the accuracy and usefulness of the dispatch information. This potential is described further in section 5.2.2.

These options are further described in the following subsections.

5.2.2.1 Option 1

Under this option, as originally proposed, specific taxis will use the left exit lane so that the counting of normal taxis will not be affected.

Exhibit 5-3 provides a summary table showing the steps of specific taxi dispatching operation and corresponding capability of the system at various functional areas of the groundside operation with regular text indicating existing practice and italics for new system operation.

Exhibit 5-3: Option 1 of Specific Taxi Operations & CVDS Functions

Functions & Capabilities / Process	Curb-side	Holding Lot
Arrive at holding lot	• N/A	• Queue in holding lot.
Specific Taxi Needed at DTB	• Radio ITB with request	• N/A
Specific Taxi Needed at ITB	• *Enter # , type of specific taxis , and destination on handheld PC*	• *Number , type of specific taxis, and destination displayed on VMS*
Departure from holding lot	• No information	• Taxis exit over non-detectorized exit (left) lane
Arrival at ITB	• Visual confirmation • *Cancels request*	• *VMS is updated with cancelled request*
Passenger Handling	• No effect on the system	• No effect on the system
Arrival at DTB	• Visual confirmation	• N/A

5.2.2.2 Option 2

Under this option, specific taxis will also use the detectorized exit lane. Counting down of the taxi requirements on the VMS will be done in the order that the requests are displayed on the VMS. Exhibit 5-5 illustrates how the requests and VMS would work.

Exhibit 5-4 provides a summary table showing the steps of specific taxi dispatching operation and corresponding capability of the system at various functional areas of the groundside operation with regular text indicating existing practice and italics for new system operation.

Exhibit 5-4: Option 2 of Specific Taxi Operations & CVDS Functions

Functions & Capabilities / Process	Curb-side	Holding Lot
Arrive at holding lot	▪ N/A	▪ Queue in holding lot.
Specific Taxi Needed at DTB	▪ Radio ITB with request	▪ N/A
Specific Taxi Needed at ITB	▪ *Enter # , specific type of taxi , and destination on handheld PC*	▪ *Number ,specific type of taxi, and destination displayed on VMS*
Departure from holding lot	▪ *Hand-held device shows count down of the number of taxis still required*	▪ *Taxis exit using detectorized exit lane* ▪ *Dispatch number on VMS may or may not countdown to zero depending on the # of general taxis requested & exiting.*
Arrival at ITB	▪ Visual confirmation ▪ ITB GTP dispatches specific taxi to DTB	▪ N/A
Passenger Handling	▪ No effect on the system	▪ No effect on the system
Arrival at DTB	▪ Visual confirmation	▪ N/A

Exhibit 5-5 provides an example of requests and VMS displays under this option.

Exhibit 5-5: Example of Requests & VMS Displays Under Option 2

Results / Requests	Taxi movements	VMS
Request #1 for 12 general taxis	None yet	Line 1 shows 12 needed
None	3 taxis leave by right lane	Line 1 shows 9 needed
Request #2 for 8 general taxis	None yet	Line 1 shows 9 needed Request #2 pending
Request #3 for 2 wheelchair taxis	None yet	Line 1 shows 9 needed Line 2 shows 2 WAT needed Request #2 pending
Request #4 for 7 general taxis	None yet	Line 1 shows 9 needed Line 2 shows 2 WAT needed Request #2 pending Request #4 pending
None	9 taxis leave by right lane	Line 1 shows 8 needed (request #2) Line 2 shows 2 WAT needed Request #4 pending
None	2 taxis leave by right lane	Line 1 shows 8 needed (request #2) Line 2 shows 0 specific taxis needed, and then the request is removed from the VMS Request #4 pending
None	3 taxis leave by right lane	Line 1 shows 5 needed (request #2) Request #4 pending

Exhibit 5-5 presents a scenario that describes the order by which the countdown logic would be applied (i.e., in order of receipt – irrespective of the actual vehicle types exiting). The above example presents only one case, whereby no error is generated due to the availability and order by which the taxis exited. If the specific taxis leave the holding area prior to the complete countdown of the general taxis, a temporary error would result on the sign. The advantages and disadvantages of each of these options were discussed at length with the end users. Their experience with managing the taxis at the airport indicated that there will be very few instances where regular taxis and specific taxis are both required at the same time, and thus the potential for error would be minimal. This option was selected for implementation.

5.2.2.3 Option 3

Taxis exit using the second lane (proposed to not be detectorized); however, the second exit lane is also detectorized, with a loop and height detector, which will be used to distinguish buses, and thus assume all other vehicles are specific taxis for proper countdown on the VMS and hand-helds.

Exhibit 5-6 provides a summary table showing the steps of specific taxi dispatching operation and corresponding capability of the system at various functional areas of the groundside operation with regular text indicating existing practice and italics for new system operation.

Exhibit 5-6: Option 3 of Specific Taxi Operations & CVDS Functions

Functions & Capabilities / Process	Curb-side	Holding Lot
Arrive at holding lot	▪ N/A	▪ Queue in holding lot.
Specific Taxi Needed at DTB	▪ Radio ITB with request	▪ N/A
Specific Taxi Needed at ITB	▪ *Enter # , specific type of taxi , and destination on handheld PC*	▪ *Number, specific type of taxi, and destination displayed on VMS*
Specific Taxi Departure from holding lot	▪ *Hand-held device shows count down of the number of taxis still required*	▪ *Taxis exit using 2nd detectorized lane (with height detection)* ▪ *Dispatch number on VMS counts down to zero*
Arrival at ITB	▪ Visual confirmation ▪ ITB GTP dispatches specific taxi to DTB	▪ N/A
Passenger Handling	▪ No effect on the system	▪ No effect on the system
Arrival at DTB	▪ Visual confirmation	▪ N/A

5.3 Buses

There are two types of buses:

- buses that are registered with the airport with an authorized decal number
- non-registered buses

Both types of buses arrive at the holding area and call the Dispatch Office to inform of their arrival. The Dispatch Office will enter the bus information into the existing CVI system as to the bus type, passengers to be picked up, etc.

When a tour group arrives at the curb, the Dispatch Office is notified by the tour operator. The Dispatch Office will then use the CVDS workstation to display the required bus I.D. (comprising company and bus number) and the assigned parking stall at the terminal, onto the VMS. The dispatching information for buses will be displayed on the fourth to eighth lines of the VMS. If possible/available the CVDS will include a list of the registered buses so that the Dispatcher can pick from a drop down menu the list. The dispatcher will still be able to enter in new bus details for non-registered buses. Only the CVDS system server will communicate with the VMS. No interface will be provided with CVI system/database.

The buses will exit the holding area using the left exit lane without the detector. This will not affect the counting of taxis using the detectorized lane.

Exhibit 5-7 provides a summary table showing the steps for the bus dispatching operation and corresponding capability of the system at various functional areas of the groundside operation, with regular text indicating existing practice and italics for new system operation.

5.4 General Messages

The Dispatch Office workstation also has the ability to show free form messages on the VMS on user-selected rows of the display. These messages would be added and removed manually by the dispatch office and would override the normal use of those rows.

Exhibit 5-7: Bus Operations & CVDS Functions

Functions & Capabilities / Process	Dispatch Office	Holding Lot
Arrive at holding lot	• Notified of arrival by bus drivers by phone	• Registered bus drivers call to Dispatch Office to inform of their arrivals • Non-registered bus drivers call to Dispatch Office to inform of their arrivals
Buses Needed at a terminal bus bay	• *Displays bus name and bus bay number at the terminal on the VMS for registered and non-registered buses*	• *VMS displays bus company name, number and the bus bay to go to at the terminal*
Departure from holding lot	• N/A	• Buses exit over non-detectorized exit (left) lane
Arrival at bus bay	• Visual confirmation using CCTV monitors • *Cancels request*	• *Request removed from VMS*
Passenger Handling	• No effect on the system	• No effect on the system

6. DESIGN & IMPLEMENTATION

Once the functional requirements and concept of operations of the system were fully defined and approved by the VIAA, the design and implementation phase commenced and included the following key steps:

System Design

- Hardware
- Software

Implementation

- Equipment Procurement
- Construction
- Integration & Testing
- Training

6.1 System Design

6.1.1 Hardware

Exhibit 6-1 presents the network architecture of the system as implemented for the VIAA; due to the flexible design of the CVDS, it is also possible to configure the system in different ways to meet the requirements of different customers. The system comprises the following major components:

- Vehicle Loop Detector (VLD)
- Variable Message Sign (VMS)
- VIAA Local Area Network (LAN)
- Workstation
- Handheld Devices
- Central Server Equipment

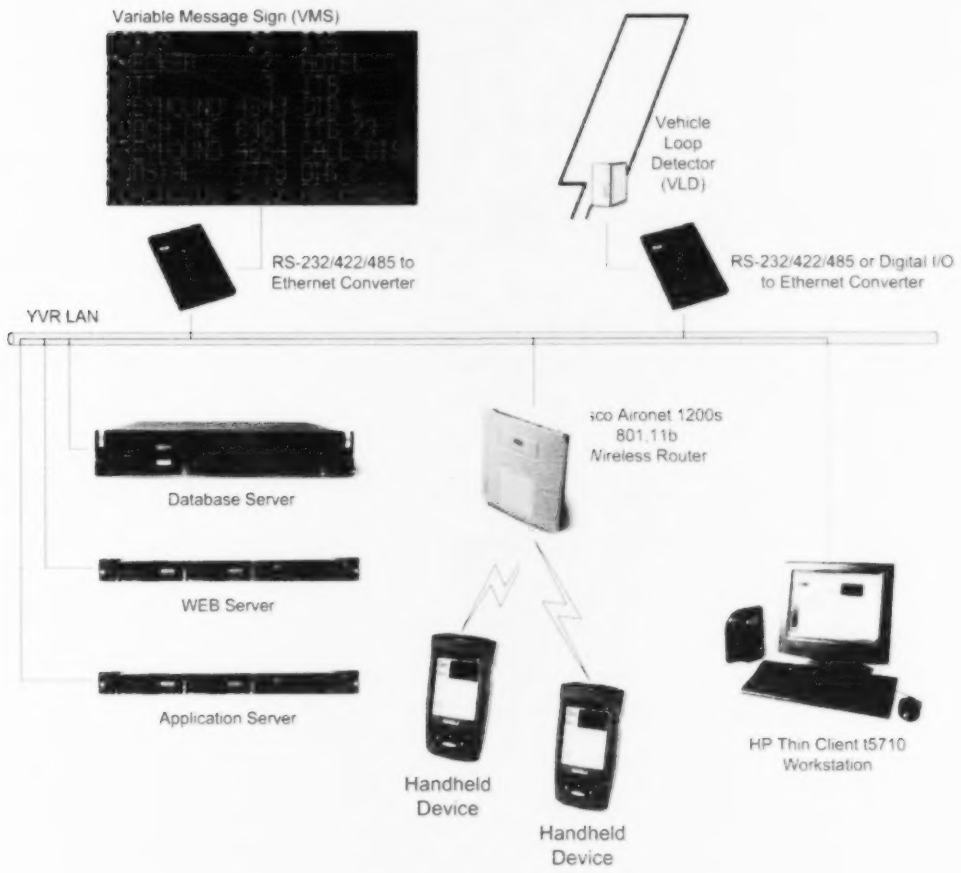
The following is the physical representation of the CVDS software and hardware configuration at the VIAA. However, due to the flexible design of the CVDS, it is possible to configure the system in different ways to meet the requirements of different customers

Equipment specifications were developed for the following major system elements:

- Field Equipment
  - Variable Message Sign (VMS)
  - Loop detector
- Computer Hardware
  - Hand-held PDAs
  - Dispatch workstation
  - Application Server

VIAA played a key role in defining the computer hardware specifications, in order to ensure consistency with internal IT requirements; IBI Group assisted in reviewing those specifications to ensure compatibility with the overall system.

Exhibit 6-1: System Architecture



6.1.2 Software

The software design was carried out by preparing a detailed software requirements specification document that translated the functional requirements documented in the concept of operations into specific modules for coding. Exhibit 6-2 presents the top-level data flow diagram of the system, along with a physical architecture overlay that correlates major processes to system servers. This served as the starting point of the software design. The following is one possible physical representation of the CVDS software and hardware configuration. However, it is possible to combine the software processes to suit the airport's desired configuration.

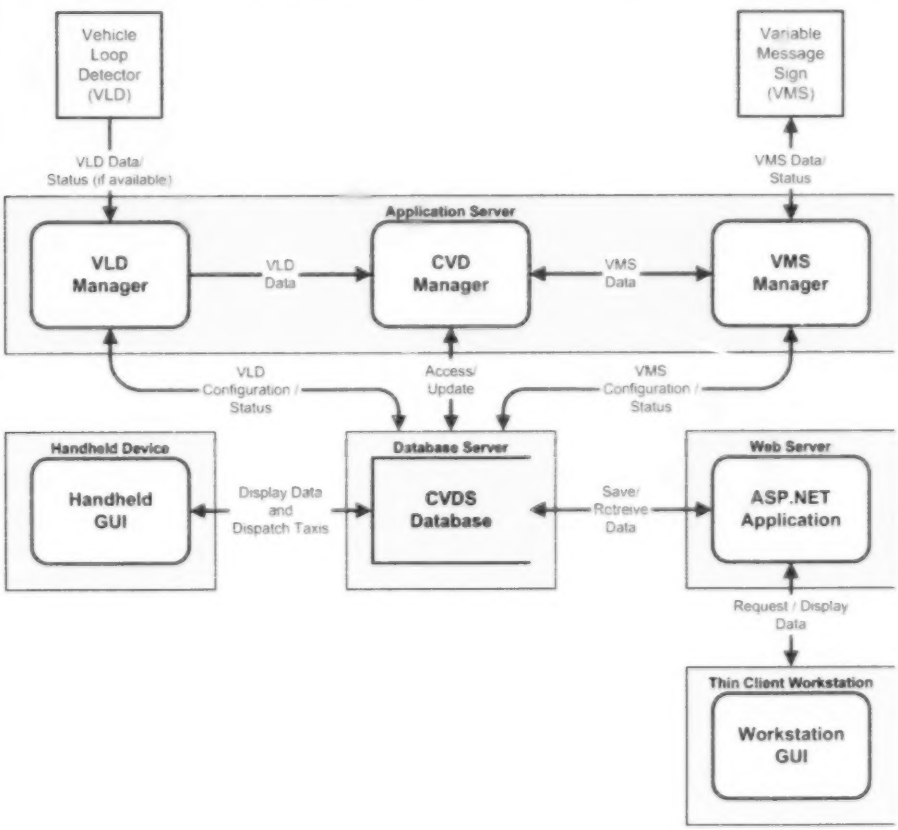
The following is a brief description of each of the modules in the system, as illustrated in Exhibit 6-2:

- Variable Message Sign (VMS) Manager: communicate with the VMS controller in real-time, update the VMS contents as required, handle page based scrolling and manage VMS controller status updates.

- Vehicle Loop Detector (VLD) Manager: handle notification that a vehicle has passed over the detector and manage status updates from the vehicle detector.
- Commercial Vehicle Dispatch (CVD) Manager: inform VMS Manager about changes to the sign contents, store detected vehicle transactions in database and determine threshold status.
- Workstation GUI: allow dispatch personnel to dispatch commercial vehicles, register commercial vehicle companies, request general and specific taxis, display free-form messages on the sign, view the current VMS display data and print system reports.
- Handheld GUI: allow operators to request general and specific taxis, view current VMS display data and monitor device status.
- CVDS Database: keep a log of the number of vehicles detected, every taxi request and every dispatched commercial vehicle.

The configuration shown here involves the use of three servers. The Application Server hosts the VLD Manager, the VMS Manager and the CVD Manager. The Database Server hosts the CVDS Database. The Web Server hosts the CVDS ASP.NET Application. The Handheld Device will run the Handheld GUI. The Thin Client Workstation provides browser access to the Workstation GUI.

Exhibit 6-2: Top Level Data Flow Diagram with Physical Architecture Overlay



6.2 Implementation

The implementation phase was carried out jointly by the VIAA and IBI Group. Here, the airport led the procurement of the sign and loop detector infrastructure, and managed their associated construction and installation activities. IBI Group led the software installation, testing and overall system integration task, ensuring that all components are functioning as intended, and fully integrated with the CVDS software.

Training material was prepared by IBI Group, and the training of staff was carried out by VIAA. The system went into full operation in June of 2006.

7. CONCLUSIONS & RECOMMENDATIONS

This section presents the conclusions from this project, in terms of benefits and lessons learned, and provides recommendations on possible next steps for the airport and ITS community to take further advantage of this deployment.

7.1 Benefits

The CVDS implemented at the VIAA introduces a number of functional benefits relative to the systems and methods previously used for dispatching commercial vehicles. These benefits can be summarized in terms of the following functional categories related to ground transportation management:

- **Requests:** The ability to request commercial vehicles has been enhanced significantly as a result of the system's capabilities. Specifically, through the use of a hand-held PDA, GTP can now request any quantity of taxis (previously limited to 9), can request specific types of taxis, and can specify one of three destinations for the taxis to proceed to. In addition, the dispatch office now has a feature-rich web-based application for requesting buses, generating reports, detecting faults in the system – as well as performing all of the functions of the hand-held PDA.
- **Displays:** The ability for commercial vehicles to take advantage of the enhanced requesting capabilities has also been significantly enhanced. The holding lot is now equipped with a large (8-line) dynamic message sign that is used to display requests for taxis, specific taxis, and buses. With the larger sign, requests now include quantity and destination, with good visibility from the back of the holding lot. The sign display is also integrated with a vehicle detection system (see below) that counts down the number of taxis and/or specific taxis in the order that they were requested. Finally, the web based interface of the application is used to display an image of the sign contents on a monitor in the lunch room of the holding lot, so that drivers not in their vehicles can stay abreast of the dispatch requirements.
- **Monitoring:** The graphical user interface of the web based application, and the hand-held PDA provide significantly enhanced monitoring capabilities that allow the GTP to quickly review what is currently being displayed on the sign, and what requests are queued up for display.
- **Detection:** The detection capability at the exit of the holding lot has been upgraded with current technology, providing for a cost effective way of detecting exiting vehicles for the purposes of updating the sign. A two-loop configuration has been used for redundancy purposes.

In addition to the above discreet functional benefits, the following additional "over-arching" benefits should be noted:

- **Safety and Congestion:** The old dispatch sign could only request up to 9 taxis at one time. Whenever more than 9 taxis were required, the dispatch office had to use the PA system to call for taxis. This would frequently result in too many taxis coming to the terminal. When a PA announcement was made for 20 taxis, there was no system to countdown those taxis. Therefore the taxi drivers were forced to guess when 20 taxis had left the holding lot.

  Understandably, more taxis than 20 would often appear at the terminal. This would cause backups and the surplus taxis would queue back into the roadways surrounding the terminal.

  In the summer of 2006 construction started on elevated mass transit from the airport to downtown Vancouver (Canada Line). As a result, the area where these surplus taxis would

park was no longer available. It became a very important safety issue that the number of taxis that were needed was matched by the number of taxis that drove up to the terminal.

The new CVDS has delivered this needed ability to accurately supply taxis to the terminal. The GTP can request any number of taxis that are needed at the terminal. That number is posted on the VMS and is accurately counted down, so only the right number of taxis will respond to the request. Finally, because the system is accurate, actions can be taken against over-zealous taxi drivers if the need was to arise.

Another improvement in reducing congestion at the terminal has occurred during the busiest times for needing taxis. With the old system, the dispatch office would use the PA for 20 taxis, for example. If there were only about 20 or fewer taxis in the hold lot at the time, the lot would become empty. The next taxi drivers who would be approaching the hold lot would see that the hold lot was empty and they would assume taxis were needed at the terminal, and would just drive straight to the terminal.

With the new CVDS, if a request was posted for 20 taxis and all 13 taxis in the hold lot drove to the terminal, the VMS would show that 7 more taxis are still required. The next 7 taxis that enter the hold lot will read the VMS and drive to the terminal. The requirement will have been fulfilled and so the next taxis will see nothing on the VMS and so will wait in the hold lot for the next request to be posted.

- **Expanded use:** The intent of the CVDS was to manage taxis and buses. Now that the system is in use, it may be used for delivery trucks as well. Similar to the situation for the buses, there are a limited number of loading bays for delivery trucks at the terminal. So, delivery trucks also report to the hold lot and wait to be told when and where they can come up to the terminal.

  To date, the delivery trucks are still being paged using the PA system. However as the new CVDS becomes more established, it is likely that its functionality will be used for delivery trucks as well.

- **Reliability:** The new CVDS is far more reliable than the old system. Although this is not surprising considering that the old system was installed in the 1970s, it has been welcomed by the users and operators of the system. The unreliability of the old system reached a level where a "reset" button was installed at the base of the old sign so that the taxi drivers could be asked, via the PA, to press the reset button and thus get the old system working again. The new VMS, loop detector and PDAs are all performing very well and this reliability is very much appreciated by all of the users of the new system.

- **Data Analysis:** The reports available within the CVDS make it easier to analyse the historical requirements for different types of taxis and buses. After some significant data has been collected, VIAA will be able to determine typical taxi requirements and typical response times by the taxis. This information may be useful in verifying that an appropriate number of taxis are servicing the airport.

The sections that follow discuss how the system's benefits apply to various beneficiaries either individually as a whole. These beneficiaries include:

- Airport Ground Transportation Management Operations
- Commercial Vehicle Operators
- Passengers
- Environment
- Other airports
- ITS Community at large

7.1.1 AIRPORT GROUND TRANSPORTATION MANAGEMENT OPERATIONS

The ground transportation management operations at the airport will incur a number of benefits. These benefits can be categorized in terms of the following:

- **Resource Optimization:** is achieved because the GTP can now perform more functions from the curb relative to prevailing demands without having to rely on the dispatch office as much. Furthermore, the dispatch office can perform its functions better by using the sign to dispatch buses.
- **Increased Reliability:** is achieved because the dispatch requests to the holding lot include more details, and because both the GTP at the curb and the dispatch office are able to verify what is being displayed on the sign, and the number of taxis that have exited in response to a request.

7.1.2 COMMERCIAL VEHICLE OPERATORS

The commercial vehicle operators in the holding lot will incur a number of benefits. These benefits can be categorized in terms of the following:

- **Better Information:** is provided through the use of a sign that serves all of the vehicles in the holding lot, eliminating the need for some vehicles to use the PA system, and others to use the sign. Furthermore, the information includes required destination, eliminating the need for further staging at the ITB before being sent to the DTB or the hotel. Finally, the information is current, in that the required number of taxis is counted down, and the bus requests are removed from the sign upon their arrival at specified destination.
- **Increased Exposure:** is achieved by way of the size of the sign, which includes 8 lines, and is legible from the back of the holding lot. Furthermore, the same information on the sign is available in the holding lot lunch-room by way of a monitor.

7.1.3 CUSTOMERS

The combined benefits to the ground transportation management operations at the airport, and the commercial vehicle operators, results in a reduction of passenger wait times at the curb. Specifically:

- the optimization of resources at the curb allows the GTP to respond to prevailing requirements (i.e., need for a taxi or specific taxi) more efficiently which helps ensure an adequate supply of the right type of vehicle at the curb to serve customer requirements;
- the provision of better and more accessible information to the commercial vehicle operators results in a quicker response from the holding lot, again resulting in the supply of the right type of vehicles at the curb to serve customer requirements

7.1.4 ENVIRONMENTAL BENEFITS

There are two direct environmental benefits resulting from the installation of the new CVDS:

- **Reduced emissions:** is achieved by way of a reduction in the amount of unnecessary vehicle idling at the terminal curbs. Because of the limitations and inaccuracies of the old method of dispatching, there would often be a need to over-supply the curb with taxis as a means of managing customer wait times. The enhanced ability of the new system to make the dispatching activities more dynamic and relative to curb requirements minimizes the unnecessary curb side idling.
- **Reduced noise pollution:** is achieved as a direct result of using the dynamic message sign for all dispatching requirements, instead of the previous method of dispatching of

specific taxis and buses through the PA system. The PA system was loud and could be heard by the residents north of Sea Island in the Arbutus and South West Marine Drive area.

7.1.5 OTHER AIRPORTS

Two of the features of this system create an opportunity for other medium and small sized airports to deploy commercial vehicle dispatch systems with relatively low costs; these include:

- A reliance on loops instead of AVI. This allows simple counting of vehicles exiting a holding area without the infrastructure requirements of AVI.
- Use of a web based application for dispatching purposes, accessible from any secure computer and internet connection; this allows airport that do not have a dispatch office to perform dispatch functions out of other office and administrative areas.

7.1.6 ITS COMMUNITY

The ITS community at large has benefited from this deployment project as a result of the innovative use of hand-held PDAs, wireless networks, and web based applications for controlling variable message signs using industry standard protocol of NTCIP.

7.1.7 PROJECT IMPLEMENTATION METHODOLOGY

As noted earlier, the implementation of this project was shared between IBI and the VIAA. IBI provided all of the software development and domain knowledge from the ITS community. The VIAA provided the hardware procurement and installation tasks, and provided local domain knowledge. This partnership worked well to deliver a working system that met the needs of the users.

The development and testing of the new system was, in a sense, "fast-tracked". Using IBI's computer systems, the system was developed and tested long before the VIAA computers were installed. Even before the software development was started, paper mock-ups of the PDA and desktop GUIs were presented to, and approved by, the end users. When the actual system was delivered, there were no surprises as they had already seen it all 'working', albeit on paper.

As the software development progressed, the software was tested and issues raised and fixed right away. This cycle was repeated until the development was complete. An alternative project plan would have been to develop the software in isolation, and not commence testing until all of the VIAA hardware was installed. In this case, that would not have been as effective or as timely as the approach that was taken.

7.2 Lessons Learned since Implementation

The new CVDS has now been in use at the VIAA for over 6 months. The system has been well accepted by the users (GTP) and the drivers. After the first few months of use, the old system was decommissioned and physically removed from the hold lot. This demonstrated the users' preference for the new system and their confidence in it. Recently, the manual method of counting requested taxis has been terminated in favour of using the statistical reports available from the CVDS. This saves the manual work and will provide consistent results.

Both the curbside and dispatch office GTP are happy with the new CVDS and have no interest in returning to the old system, even if it was available. The desire of the VIAA is to demonstrate this new system to other airports and similar facilities so that they can also benefit from it.

Since the implementation of the system, the following early lessons have been learned about the design of the system.

7.2.1 VMS

From the beginning of the project, the physical layout of the holding lot was identified as a challenge for VMS readability. The back of the holding lot is about 275 m from the sign location (refer to Exhibit 3-1 for an overview of the lot layout). Using the industry standard for a viewing distance of 6 m per centimetre of font height, an exceedingly large sign would be required in order to ensure that the VMS would be readable at the back of the lot; this would then be difficult to read at the front of the lot where vehicles are only 30 m from the sign. Working with the VMS manufacturer, a sign using a 30 cm high font was selected, being officially viewable to a distance of 185 m.

The result has been that the VMS is very readable throughout much of the lot, especially in the taxi section where the vehicles all face towards the front of the lot. Due to the quality and resolution of the sign, the readable distance is actually about 230 to 245 m. As expected, the challenge has been with the readability of the VMS for the buses, since they park on an angle to the VMS and the sign is readable for only the buses in the front half of the lot.

For most of the year, this is not a problem because at any given time the number of buses in the lot will fit into the front half where the sign is legible to the buses. However, during summer peak periods, the lot can be full of buses and those at the back cannot read the sign. For those 3 to 4 months, the PA system is used to dispatch buses.

Depending on the experience and feedback from the users, there may be an initiative to install additional "repeater" VMS in the back half of the lot. These signs would be oriented to directly face their audience, i.e. a sign facing the taxis would carry only the taxis messages, and a sign facing the buses would carry only the bus messages. The CVDS software supports multiple VMS and can easily be adapted to filter the content for different signs. These signs, if implemented, would be done outside of this project based on the demand and the availability of additional resources.

7.2.2 SILENT SYSTEM

One of the goals of the new system was to have a "silent system", i.e. no reliance on a PA system. Initial feedback from the drivers indicates that they would like an audible alert when a new message was posted on the VMS. This would get them to look up at the sign. The initial implementation has been done without any use of the PA system by the new CVDS software.

After the system has been in use for some time, VIAA will survey the drivers to see if the audible alert is still desired or if it was an initial reaction to the new system. If an audible alert is needed, its design requirements will need to be investigate to determine whether the alert would be triggered by the CVDS software (i.e., every time it sends a message to the sign), or by the sign (i.e., every time it receives a message) etc. The alerts, if implemented, would be done outside of this project based on its technical feasibility and the availability of additional resources.

7.2.3 PDA

Selecting a suitable wireless device was quite a challenge. The working environment is outdoors and mobile, so the device had to be portable and weather proof. There is a number of rugged tablet PCs but they are quite heavy when considering that the users will be carrying it for many hours during their shift. There are some established rugged PDAs, but those tend to weigh over one pound which was considered too heavy as well. A regular PDA placed inside a weatherproof/drop proof case was trialled, but they became very bulky, although they were not heavy. Also, the PDA needed to be removed from the case for recharging, which was not desirable.

During the course of this project, a new rugged PDA was being brought to market. The Durateq 3100 (www.durateq.com) is a rugged version of the standard HP iPaq PDA, and is not just an iPaq in a rugged case. It weighs only about 5 ounces, is sufficiently weatherproof for operating needs (IP54 rated), and does not have a lot of buttons. A unit with too many buttons was not preferred because the CVDS application was designed to rely only on the touch-screen capabilities so inexperienced users would not be intimidated.

A number of pre-production models of the Durateq product were obtained for testing and met all of VIAA's needs for using the system. As the production units became available the test units were swapped for "real" units. This extra effort was very worthwhile, because the users ended up being very happy with the product and had participated in the selection of a device that they have to use all day.

7.2.4 COLLABORATIVE APPROACH TO IMPLEMENTATION

During the implementation phase, technical staff from IBI and VIAA worked closely together. This resulted in a smooth integration phase where the new hardware and software were integrated seamlessly in the IT environment at VIAA.

7.3 Recommended Next Steps

For the VIAA the possible next steps that can follow this implementation include expansion of the system to include more Variable Message Signs, CCTV monitoring of the commercial vehicle holding lot, as well as integration with existing systems which manage the taxis and commercial buses for other purposes.

For the ITS Community at large, next steps can include marketing of this system to other airports across Canada who require a low cost and high-tech solution for ground side commercial vehicle management. Furthermore, the underlying architecture of this system can contribute to the updating of the Canadian ITS Architecture and the development of specific market packages for ground side commercial vehicle management at terminals.